KELLER & PARTNER
PATENTANWÄLTE AG

Werner A. Roshardt
Patentanwalt VSP
European Patent Attorney
Dipl.-Phys. ETH

Dr. Jürgen Junghans
Patentanwalt
Dipl.-Ing. Elektrotechnik
Physiker

Dr. Anton Steiner
Patentanwalt
Dipl.-Phys. ETH

Roman Stäbler
Patentanwalt
Dipl. El.-Ing. ETH

Dr. Philipp Rüfenacht
Patentanwalt
Dipl.-Phys. UniBE

Schmiedenplatz 5
Postfach
CH-3000 Bern 7
Switzerland
Telefon +41 (0) 31 310 80 80
Telefax +41 (0) 31 310 80 70/71
info@kellerpatent.ch
www.kellerpatent.ch

Bank CS Bern 398 655-81
(BLZ 4094)

Postkonto 30-22853-1

by fax and REGISTERED

European Patent Office
80298 Munich
DEUTSCHLAND

Bern, 12 May 2004/nr
our ref. RS/RS-16075
your ref.

Our File 16075
International Patent Application No. PCT/CH2003/000246; Delta Energy Systems (Switzerland) AG,
Written Opinion of 13 January 2004

Dear Sirs,

1 Amended claims 1 to 31

As a reaction to the Written Opinion of 13 January 2004 and your confirmation of the extension of the time limit of 20 April 2004 with respect to the international patent application in caption please find enclosed a new set of claims with the claims 1 to 31 (replacement sheets 11 – 17). The examination shall be carried out on the basis of the new claims.

The amendments in the claims particularly are:

- The original claims 9 and 14 have been deleted. The claim numbers and the claim dependencies have, unless otherwise listed below, been amended accordingly.

- In the original claim 1 the term "at least two flux-conducting magnetic elements" has been amended by inserting the word "core" before the word "elements" (amendment is based for example on the description on page 3, line 29 to page 4, line 1). Furthermore, all features of original claim 9 have been incorporated into new claim 1 by adding the term "wherein the core arms and core elements form a single, unbranched, closed flux path, whereby all of the primary and secondary windings are linked by the same flux" at the end of claim 1.

- The claim dependency of original claim 11, that is new claim 10, has been changed from claim 9 to claim 1.

- In the original claim 13, the term "forming a continuing, closed magnetic path" has been replaced by the term "forming an unbranched, closed magnetic flux path".

- In the original claim 14, the term "to form a transformer core that has a single, unbranched flux path" has been amended by inserting the word "closed" before the word "flux".

- In the original claim 21, the term "to form a single, branchless flux path" has been amended by inserting the word "closed" before the word "flux".

The amendments in claims 13, 14 and 21 are based for example on the discription on page 3, lines 12-13.

2 Short comment to the cited prior art

2.1 WO 00/11687, Fricker et al.

The disclosed transformer has multiple voltage outputs, a reduced physical size and secondary windings in a mirror configuration. Because there are two secondary windings in a mirror configuration, the coupling with the flux over a full cycle is balanced. The primary windings may be in a series configuration. Each secondary track has several segments which are serially interconnected. In order to provide a plurality of (different) output voltages (e.g. for a PC) the transformer is connected to switching circuitry which selectively switches between the first and the second secondary track. The core is always E-shaped and the primary and secondary windings encircle the central leg.

All transformers disclosed in this reference have an E-type core, which has at least two different flux paths. In contrast to the invention Fricker does therefore not disclose a transformer with a single, unbranched magnetic flux path.

2.2 US 2001/0020886 A1, Murata Manufacturing

The disclosed coil device has a core unit with an intermediate leg and at least two external legs at the same distance. A first and a second printed coil are provided on a first and on a second PCB. While the first printed coil encircles the central leg, the second coil has two segments encircling the external legs by the same number of turns but in opposite direction and being connected in series. By using four PCBs on top of each other which are penetrated by the legs of the common core unit two transformers may be implemented: The first transformer T1 of the switching power supply is used for power transmission while the second transformer is for control and drive purposes.

Again Murata does not disclose a transformer with a single, unbranched magnetic flux path.

2.3 US 6,069,548, Nokia

The primary and secondary windings of the disclosed planar transformer are implemented in their entirety on a separate piece of a supplementary circuit board. The first PCB has a hole and connection areas for soldering the contacts of the second PCB.

In this US-Patent no transformer with a single, unbranched magnetic flux path is shown.

3 Patentability

None of the cited references discloses or gives a hint to provide a circuit board having the claimed features and particularly a transformer with a core that forms a single, unbranched magnetic flux path. Since all new independent claims 1, 13, 14, 21 and 31 incorporate this feature, these independent claims are new and involve an inventive step.

All other claims depend on one of the independent claims. Hence, these claims are new and involve an inventive step too.

Therefore, all claims 1 to 31 of the new set of claims define patentable subject matter.

4 Examination report

As the new set of claims overcomes all of the objections of the Written Opinion a positive international preliminary examination report can be expected.

In the case the examiner requires further clarifications or does not agree with the above comments he is kindly asked for a call-back.

The representative:

Keller & Partner
Patentanwälte AG

Werner A. Roshardt, Patent Attorney

- replacement sheets 11 - 17 with new claims 1 to 31
- form for acknowledgement of receipt of record copy (only by mail)

10/512128
12 Rec'd PCT/PTO 12 OCT 2004

We claim:

1. A magnetic circuit element including a circuit board, at least two flux-conducting magnetic core arms penetrating the board, at least two flux-conducting magnetic core elements extending between the magnet core arms, one on each side of the circuit board, at least two series-connected primary windings on the board in at least partially encircling relation to at least one of the arms and at least two parallel-connected secondary windings on the board in at least partially encircling relation to at least one of the arms wherein the core arms and core elements form a single, unbranched, closed flux path, whereby all of the primary and secondary windings are linked by the same flux.

2. The magnetic circuit element according to claim 1, wherein the circuit board is a multilayer circuit board and at least one of the windings is a buried winding located between layers of the multilayer circuit board.

3. The magnetic circuit element according to claim 2, wherein each of the windings is a buried winding located between layers of the multilayer circuit board.

4. The magnetic circuit element according to claim 2, further comprising circuit component, including one or more power components, occupying at least one outer surface of the circuit board above or below the at least one buried winding.

5. The magnetic circuit element according to claim 1, wherein each of the primary windings has substantially the same number of turns as each other secondary winding.

6. The magnetic circuit element according to claim 5, wherein each of the secondary windings has substantially the same number of turns as each other secondary winding.

7. The magnetic circuit element according to claim 1, wherein the number of primary windings is the same as the number of secondary windings, each primary winding being wound in closely coupled relation to a secondary winding.

8. The magnetic circuit element according to claim 6, wherein the number of primary windings is the same as the number of secondary windings, each primary winding being wound in closely coupled relation to a secondary winding.

9. The magnetic circuit element according to claim 2, wherein all of the core arms and core elements are selected from the group consisting of C and I elements.

10. The magnetic circuit element according to claim 1, having an even number of core arms in excess of two.

11. The magnetic circuit element according to claim 10, having in excess of two magnetic core arms penetrating the board, each core arm being wound with at least one of the primary and secondary windings.

12. The magnetic circuit element according to claim 11, wherein each core arm is wound with at least one of the primary windings and at least one of the secondary windings.

13. A multilayer printed circuit board of the kind having first and second surfaces on first and second sides of the board and including a transformer with windings defined between layers of the board and a transformer core penetrating the layers of the board and about which the windings are wound; the improvement comprising; a plurality of at least four magnetic core segments extending through the board from the first side to the second side at spaced apart locations;

a) said windings comprising a plurality of at least four windings, each at least partially encircling a separate one of the core segments where the core segments extend through the board;

b) a plurality of substantially planar first magnetic core elements at the first side of the board, each of the first core elements extending between a pair of the magnetic core segments in flux-conducting relation thereto such that each core segment at the first side of the board is joined in flux-

conducting relation to another of the core segments by one of the substantial planar core elements at the first side of the board; and

c) a plurality of substantially planar second magnetic core elements at the second side of the board, each of the second magnetic core elements at the second side of the board extending between a pair of the magnetic core segments in flux-conducting relation thereto, each pair of core segments between which a second magnetic core element extends at the second side of the board being in a separate pair of the core segments joined in flux-conducting relation by first magnetic core elements at the first side of the board;

the magnetic core elements and core segments forming an unbranched, closed magnetic flux path extending across the first and second faces and through the layers of the board.

14. A method of power conversion for providing high amperage, low voltage power including:

(a) providing a printed circuit board,

(b) forming holes through the printed circuit board,

(c) locating magnetic core arms in the holes formed in the printed circuit board,

(d) locating magnetic core elements in flux-conducting relation between the core arms on opposite faces of the printed circuit board to form a transformer core that has a single, unbranched,closed flux path,

(e) winding a plurality of series-connected windings, on the core arms to form a transformer primary,

(f) winding a plurality of parallel-connected windings, on the core arms to form a transformer secondary.

15. The method according to claim 14, further comprising providing a plurality of output treating circuits at the output of each of the windings forming the secondary, the output heating circuits being connected between these windings and a current additive point of connection of the windings.

16. The method according to claim 14, wherein the steps of winding the series-connected windings and winding the parallel-connected windings comprises winding at least one of the series-connected windings in closely coupled relation to one of the parallel-connected windings on each of the core arms.

17. The method according to claim 16, wherein forming holes in the printed circuit board comprises forming in excess of two holes therein, and the step of locating magnetic core arms in the holes comprises locating in excess of two core arms, winding a plurality of series-connected windings comprises winding in excess of two series-connected windings on the core arms, and winding a plurality of parallel-connected windings comprises winding in excess of two parallel-connected windings on the core arms.

18. The method according to claim 17, wherein each step of winding comprises printing or depositing a winding on a surface of the printed circuit board in at least partially encircling relation to one of the core arms.

19. The method according to claim 14, wherein each step of winding comprises printing or depositing a winding on a surface of the printed circuit board in at least partially encircling relation to one of the core arms.

20. The method according to claim 14, wherein the step of providing a printed circuit board comprises providing a multilayer circuit board, and the steps of winding a plurality of series-connected and parallel-connected windings comprise providing at least a plurality of windings as buried windings on one or more layer surfaces intermediate the opposite faces of the printed circuit board.

21. A multilayer printed circuit comprising:

(a) a multilayer circuit board having first and second faces,

(b) a transformer including:

(i) a magnetic core having:

(A) a plurality of core arms, each of which extends through a hole in the multilayer circuit board from the first face to the second face,

Neue Seite I vom 13.01.04/
12.05.04 nr

(B) a plurality of magnetic core elements, each extending along the first or second surface between ends of the core arms to complete a magnetic circuit comprised of the core arms and core elements to form a single, branchless, closed flux path,

(C) at least two series-connected windings forming a transformer primary printed on the multilayer circuit board, each in at least partially encircling relation to a core arm,

(D) at least two parallel-connected windings forming a transformer secondary printed on the multilayer circuit board, each in at least partially encircling relation to a core arm, and

(E) each core arm extending through the multilayer circuit board having at least one of the windings of the transformer primary or secondary wound thereon,

whereby each winding couples the identical flux in the core.

22. The multilayer printed circuit according to claim 21, further comprising transformer secondary output processing circuitry connected to the parallel-connected windings, each parallel-connected winding having substantially the same output processing circuitry connected thereto for similarly processing each parallel-connected winding output, the output processing circuitry being located between the parallel-connected windings and a point of interconnection thereof.

23. The multilayer printed circuit according to claim 22, wherein the point of interconnection is current additive.

24. The multilayer printed circuit according to claim 21, wherein at least one of the windings forming the transformer primary and at least one of the windings forming the transformer secondary are buried windings printed on a face of a layer of the multilayer circuit board interior of the first and second faces.

25. The multilayer printed circuit according to claim 21, wherein each of the connected in series windings forming the transformer primary has substantially the

same number of turns as each other of the connected in series windings forming the transformer primary.

26. The multilayer printed circuit according to claim 21, wherein each of the connected in parallel windings forming the transformer secondary has substantially the same number of turns as each other of the connected in parallel windings forming the transformer secondary.

27. The multilayer printed circuit according to claim 25, wherein each of the connected in parallel windings forming the transformer secondary has substantially the same number of turns as each other of the connected in parallel windings forming the transformer secondary.

28. The multilayer printed circuit according to claim 27, wherein on each of the core arms is wound at least one of the connected in series windings forming the transformer primary in closely coupled relation to at least one of the connected in parallel windings forming the transformer secondary.

29. The multilayer printed circuit according to claim 28, wherein the number of core arms is greater than two.

30. The multilayer printed circuit according to claim 29, wherein the core elements are plates overlying the first and second surfaces of the circuit board in flux communicating relation to each core arm.

Neu auf I vom 13.09.04
am 12.05.04 IR

31. A power magnetic component including:

(a) a multilayer circuit board having first and second exterior faces,

(b) a magnetic core comprising:

(i) a plurality of magnetic segments extending through the circuit board from one exterior face to the other exterior face,

(ii) at least two magnetic elements exterior of the circuit board,

each at one of the faces, and extending generally parallel to the faces of the board in flux conducting relation from one of the segments to another of the segments to form a single, closed, unbranched flux path, and

(c) at least one buried winding carried on a surface of a layer of the multilayer circuit board intermediate the exterior faces and at least partially encircling one of the magnetic segments.